OFFICE OF
BUILDING TECHNOLOGY,
STATE AND COMMUNITY PROGRAMS

Review of Survey Data to Support Revisions to DOE's Dishwasher Test Procedure

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Executive Summary

To support revisions to the Department of Energy's test procedures for measures of energy and water consumption in dishwashers, various survey data on consumers' dishwasher usage habits were collected from a number of sources including several dishwasher manufacturers, detergent manufacturers, energy and consumer interest groups, independent researchers, and government agencies.

The findings of the review of available data on consumers' dishwasher usage habits show broad support to define:

- Consumers' pretreatment methods,
- Distribution of households by the level of soil in a dishwasher load,
- Quantitative amount of soil on the dishware, and
- Frequency of households' use of a dishwasher.

Drawing from these survey findings, the existing test method for dishwashers, and ANSI/AHAM Standard DW-1, a weighted, three-point test method using different numbers of soiled dishware is recommended to measure the energy consumption of soil-sensing dishwashers. It is further recommended that the number of average-use cycles per year be reduced into the range of 200 to 233 cycles per year.

Background

The Department of Energy's Dishwasher Test Procedure is in the process of being revised. The need to revise the test procedure is driven by the development of advanced soil-sensing dishwashers.

The introduction in the mid-1990's of advanced dishwashers equipped with the ability to sense the soil level in the dishwasher and in response to adjust the wash cycle created a challenge to the Dishwasher Test Procedure. The current test procedure, designed for fixed cycle dishwashers, measures energy consumption using a load of clean dishes. It has been well demonstrated that soil-sensing dishwashers yield lower energy consumption when tested with the clean load of dishes, as compared to when tested with soiled dishes. Therefore, current energy consumption results for soil-sensing dishwashers are not representative of the actual energy consumption of soil-sensing dishwashers in use by consumers. This inaccuracy, created by the evolution of technology, necessitates revision of the Dishwasher Test Procedure.

In addition to technology-driven change, consumers' usage of dishwashers has also changed. The most notable change in dishwasher usage is the frequency of its use. As the number of occupants in dishwasher-owning households has decreased, the occupants have grown older, and consumers eat more prepared or carryout foods, the frequency of dishwasher usage has decreased significantly.

Overview of Current Dishwasher Test Procedure

The Department of Energy's test procedures for measures of energy and water consumption (10 CFR 430.23(c)) call out measures for the energy factor (cycles per kilowatt-hour) and the estimated annual operating cost (dollars per year) of dishwashers.

These measures reference the Department of Energy's "Uniform Test Method for Measuring the Energy Consumption of Dishwashers" (10 CFR 430 Subpt. B, App. C). The current test method operates a dishwasher on the cycle recommended by the manufacturer for a full load of normally soiled dishes, but uses a test load of clean dishes. The test load consists of 8 place settings of dishware plus six serving pieces as specified in the industry-recognized standard, ANSI/AHAM Standard DW-1. The total per-cycle energy consumption of a dishwasher is based on the energy consumption measured during this test run on the normal cycle with a load of clean dishes.

Dishwashers must meet or exceed a minimum energy factor (10 CFR 430.32(f)). The energy factor for dishwashers is the reciprocal of the total per-cycle energy consumption. Standard dishwashers (currently equal to or greater than 22" in exterior width) must have an energy factor not less than 0.46 cycles/kWh. Compact dishwashers (currently, less than 22" in exterior width) must have an energy factor not less than 0.62 cycles/kWh.

It should be noted that effective June 17, 2002 that the definitions of standard and compact dishwashers will be based on place setting capacity. A standard dishwasher will be one having a capacity greater than or equal to 8 place settings plus 6 serving pieces as defined in ANSI/AHAM Standard DW-1. A compact dishwasher will be one having a capacity less than 8 place setting plus 6 serving pieces.

The estimated annual operating cost for a dishwasher is listed on a dishwasher's Energy Guide label to assist consumers in making purchasing decisions. The estimated annual operating cost for a dishwasher is based on the total per-cycle energy consumption, the representative average-use cycles per year, and the representative unit cost of energy.

Needed Test Procedure Revisions and Supporting Data Requirements

As mentioned previously, it has been well demonstrated that soil-sensing dishwashers can consume more energy when tested with a load of soiled dishes, as compared to when tested with a load of clean dishes. This indicates that the energy consumption of a soil-sensing dishwasher, as measured in the current test method, does not likely represent the total per-cycle energy consumption of a soil-sensing dishwasher in household use. Therefore, the measures derived from the total per-cycle energy consumption – the energy factor and the estimated annual operating cost- do not represent a soil-sensing dishwasher in household use.

Further, there is evidence that the representative average-use cycles per year is overstated. This means that the estimated annual operating cost of a dishwasher – whether soil-sensing or non-soil-sensing – is overestimated. Therefore, the information on the Energy Guide label is not representative and may be misleading to consumers. The Energy Guide label on a soil-sensing dishwasher is particularly impacted as the estimated annual operating cost and the total per-cycle energy consumption are not representative of household use.

The key questions in revising the test procedure for dishwashers to assure that soil-sensing dishwashers have energy factors not less than the minimum energy standard, and that the information on the Energy Guide label is representative, are:

1. How soiled are the dishes in the dishwashers of U.S. households?,
   - Quantity of soil?
   - Type of soil?
2. How are the dishwashers loaded in U.S. households?
   - Quantity of dishware?
   - Type of dishware?
3. How to reflect soiling in a modified energy consumption test method?, and
4. How often do U.S. households use a dishwasher?

The following sections present the review and analysis of a broad collection of data that lead to answers for these questions and offer an approach to incorporate the findings of the data in a revised energy consumption test procedure for dishwashers.

Data Sources

This report is based on: 1) review of existing industry and DOE dishwasher test standards; 2) review and analysis of survey information from eight individual sources including dishwasher and detergent manufacturers, energy and consumer interest groups, independent researchers, and government agencies; and 3) discussions with key personnel in industry, DOE, NIST, consumer groups and Arthur D. Little. The surveys form the core of the information to address the key questions and to guide revisions to the test procedure. They vary in size, breadth of information, and quality of information pertaining to consumers' dishwasher habits.

More than half of the surveys are nationally representative, cumulatively representing over 20,000 respondents, while the others are regional in scope. The surveys present information collected between 1997 and 2001, however most of the surveys are from the 2000-2001 timeframe. Nationally representative means that the study populations of these surveys were selected to match or was judged to distribute similarly to the U.S. Census profile of households. The demographics considered to make this selection or judgment included: market size, age of household, type of household, household size, household income, type of residence, and ownership versus rental of residence.

A key requirement of this report is to maintain the confidentiality of the industry survey sources. To this end no one industry source is referenced and the data presented is an aggregation of the survey information. However, Table 1 gives an overview of each survey's scope and size.

Table 1 – Overview of scope and size of surveys

Survey Identifier	Scope	Number of Households	Breadth of Information	Quality of Information
Survey A	Nationally Representative	> 8,000	Wide	High
Survey B	Nationally Representative	> 11,000	Wide	High
Survey C	Nationally Representative	< 1,000	Wide	High
Survey D	Regional	> 1,000	Limited	Moderate
Survey E	Regional	< 250	Limited	Low
Survey F	Regional	< 250	Moderate	Moderate

Survey G	Nationally Representative	< 500	Moderate	Moderate
Survey H	Nationally Representative	< 1,000	Moderate	Moderate
1997 RECS	Nationally Representative	5,900	Limited	High

The aggregation of the various survey data has required some regrouping of the survey results. The regrouping is necessitated because each survey may have a different number of categories or different categories for a particular habit question. The following sections address how the survey data addresses the data requirements outlined above, and how the survey data were analyzed to address those data requirements.

Detailed Findings

The findings of this review of available survey data on U.S. households' dishwasher usage habits and characteristics and of existing dishwasher test standards show broad support to address the key questions above and to make revisions to the energy consumption test procedure for dishwashers.

The available surveys provide data on a number of habits and characteristics of households with dishwashers, including:

- Households' pretreatment methods,
- Distribution of households by level of soil in a dishwasher load,
- Quantitative amount of soil in a dishwasher load,
- Frequency of households' usage of a dishwasher,
- Distribution of the type of dishware in a dishwasher load, and
- Size of the dishwasher load.

Existing dishwasher cleaning performance test standards provide much of the data on critical elements for an energy consumption test procedure for soil-sensing dishwashers, including:

- Types of soil,
- "Worst case" amounts of soil,
- Application of soils to dishware,
- Types of dishware, and
- Amount of dishware.

A majority of the recommended revisions to the energy consumption test procedure draw primarily from the survey data on the following habits and characteristics of households with dishwashers:

- Households' pretreatment methods,
- Distribution of households by level of soil in a dishwasher load,
- Quantitative amounts of soil in a dishwasher load, and
- Frequency of households' usage of a dishwasher.

Review of existing dishwasher test standards provided direction for test method elements that were either not covered or not widely covered by the surveys. These test method elements include:

- Types of soil, and
- Type of dishware

The findings below on the habits and characteristics of consumers with dishwashers, coupled with existing test methods, build to address the key questions in revising the dishwasher test procedure.

How soiled are the dishes in the dishwashers of U.S. households?

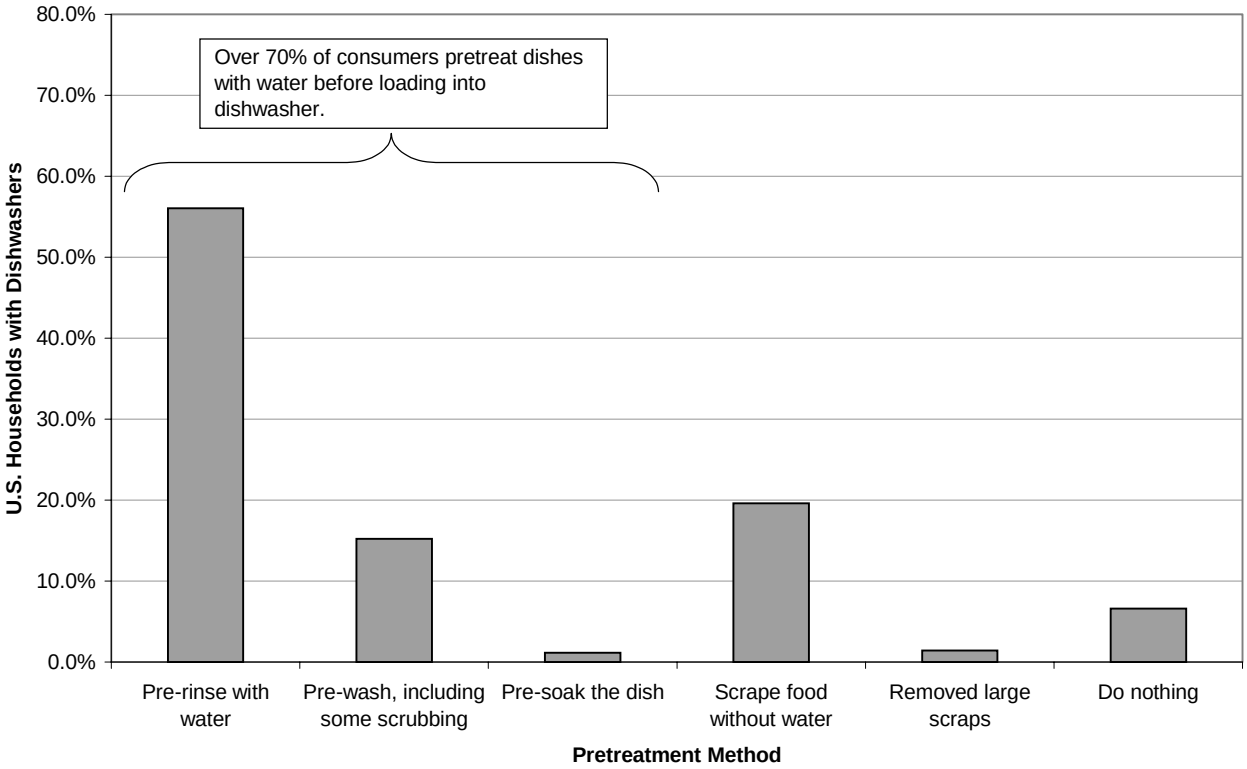
This section covers survey data and test method information available to assess 1) the quantity of soil on dishware in U.S. households and 2) the type of soil on the dishware. The quantity of soil is derived from data on pretreatment methods and resultant soil levels on dishware, qualitative ranking of soil level, and assessment of quantitative amounts associated with the qualitative ranking of soil level.

Households' Pretreatment Methods

Survey data from six of the eight sources (surveys A, C, E, F, G and H) provide information on households' pretreatment habits. Four of these surveys are nationally representative and cumulatively represent over 10,000 U.S. households.

All six of the survey sources present their data in similar categories that make aggregation of the data direct and simple. Aggregating these surveys and weighting the responses in each category by the total number of respondents indicates that more than 70% of U.S. households pretreat dishes with water prior to placing them in the dishwasher. Figure 1 shows the aggregation of the surveys' responses to questions on pretreatment habits. The simple import of this finding is that currently the vast majority of U.S. households' dishwasher loads are cleaner than they would be otherwise.

Figure 1 – U.S. Households' Dishwasher Pretreatment Habits



Distribution of Households by Level of Soil in a Dishwasher Load

Four surveys (surveys A, C, D, and F) provide a combination of qualitative and quantitative information on the soil in a dishwasher load. The first consideration is the qualitative information on the level of soil in the dishwasher loads of U.S. households.

Surveys A and C are both large, nationally representative surveys that cumulatively represent over 9,000 U.S. households. Both surveys present very similar data on the qualitative level of soil on dishware in households' dishwasher loads. The larger of these two asked households to rate the overall level of soil in their dishwasher loads. The other ranked and categorized households' description of the overall level of soil in their dishwasher loads.

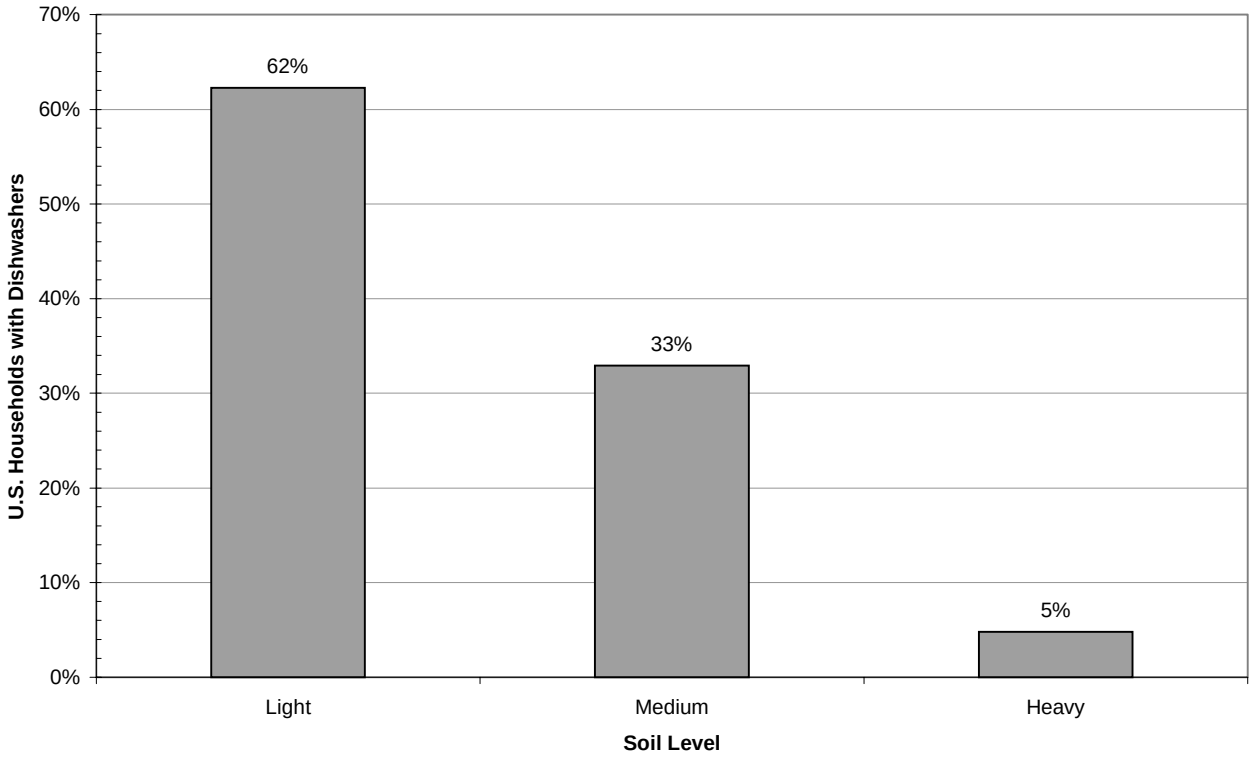
Both of these two surveys distribute the level of soil in households' dishwasher loads in three categories:

- Light level of soil,
- Medium level of soil, and
- Heavy level of soil.

Surveys D and F are regional in scope and each present their data on the level of soil in households' dishwasher loads in more than three categories. Both surveys asked households to rate the overall level of soil in their dishwasher loads against the descriptions of their categories. Although each of the two surveys has more than three categories for the level of soil, the definitions of their categories clearly allow the data to be regrouped into the light, medium and heavy categories for soil level.

Aggregating the two nationally representative sources (surveys A and C) and weighting the responses in each category by the total number of respondents yields a distribution of households within these three categories that follows approximately 62%, 33% and 5% from light to heavy, as shown below in Figure 2. Including the two regional surveys in the aggregation changes the distribution only slightly to approximately 62%, 32%, and 6% from light to heavy. In either aggregation the result is nearly the same and consistent with the finding that most households rinse dishes before placing them in the dishwasher.

Figure 2 – Distribution of U.S. Households by the Level of Soil in Dishwasher Loads



As it has bearing on determining amounts of soils representative of each of the three soil levels, it is important to note how these four surveys compare individually. Surveys A, C, and F each display very nearly the same distribution of the level of soil in households' dishwasher loads, which is essentially the distribution presented in Figure 2. Survey D also shows a similar trend. At the light level of soil survey D is consistent with Figure 2 showing approximately 62% of its respondents distribute in the light level of soil category.

However, survey D departs from the other surveys at the medium and heavy levels of soil showing rather a distribution of approximately 21% at the medium level and 17% at the heavy level. The author(s) of survey D noted concerns that some number of their respondents may not have been properly instructed on this question skewing their responses to heavier soil levels. Therefore, in the later section relating amounts of soil to the soil levels, survey D is treated with complete discounting of the responses at the heavy level.

Types of Soil

The available surveys provide only limited information on the types of soil on the dishware of U.S. households. Similarly, broader industry experience has revealed the difficulty of inventorying soil types on the dishware of U.S. households and representatively recreating those soils for the purpose of testing.

However, the Association of Home Appliance Manufacturers (AHAM) has spent considerable time and effort to define the industry-recognized, 'worst case' cleaning performance test, ANSI/AHAM Standard DW-1-1992. DW-1 precisely defines: 1) food soils that are representative of the types of soils on the dishware of U.S. households; 2) amounts of those food soils, and 3) procedures to apply

the food soils and to prepare the dishware for testing. DW-1 meets industry requirements for test repeatability.

ANSI/AHAM Standard DW-1 includes 13 food soils that are intended to be representative of the types of food soils on the dishware of U.S. households. These food soils are not intended to mirror exactly the food soils on the dishware of U.S. households. Table 2 is an excerpt from ANSI/AHAM Standard DW-1 that lists the food soils, the amounts of the food sufficient to soil a ten place table setting, and specific descriptions of the foods.

Table 2 – Soiling Ingredients from ANSI/AHAM Standard DW-1

Item	Quantity	Description
Corn	6 teaspoons (30 ml)	Cream style
Eggs	4 (50 g) minimum weight	Fresh, grade A, large
Coffee Grounds	1 ¼ teaspoons (6 ml)	Folgers, decaffeinated drip grind
Ground Beef Mixture	5 teaspoons (25 ml)	Round steak with all visible fat removed. Mix together 75% round steak with 25% kidney suet; grind together twice.
Margarine	1 tablespoon (15 ml)	Fleischmans corn oil (6 g of fat per 14 g serving) not whipped
Milk	2/3 cup (160 ml)	Carnation nofat dry
Oatmeal	5 teaspoons (25 ml)	Quaker Oats instant regular flavor (12 individual packages)
Peanut Butter	2 ½ teaspoons (13 ml)	JIF Creamy
Potatoes	13 teaspoons (65 ml)	Hungry Jack instant mashed
Preserves	10 teaspoons (50 ml)	Smuckers red raspberry
Salt	¼ teaspoon (1.25 ml)	Morton iodized
Tomato Juice	1 cup (240 ml)	Campbell's
Tomato Paste	12 oz.can	Contadina

Figure 3 shows an example of a place setting soiled with the foods specified in DW-1. However, the food soils in Figure 3 are not applied as precisely as specified in DW-1.

Figure 3 – An Example of a Place Setting Soiled with Food Soils from DW-1

Given the inherent difficulty of engineering soil types and the fact that worst case soil types have already been defined by an industry standard, and that the current test method references part of that standard, it is recommended in the best interest of DOE and the industry to use the dishware soiling procedure in DW-1 in a revised energy consumption test method for soil-sensing dishwashers.

As described in the section below, surveys have probed consumers to define the quantity of soil on their dishes and often relate the quantity of soil in terms of the DW-1 standard.

Quantitative Amount of Soil in a Dishwasher Load

This section defines quantitative amounts of soil for each of the three soil levels that characterize the distribution of soil levels found in dishwasher loads of U.S. households. Surveys C, D, and F, cumulatively representing over 2,000 U.S. households, provide text and/or graphic descriptions to link their categories of the level of soil to the three soil levels – Light, Medium, Heavy- and to quantitative amounts of soil for each level. Referencing ANSI/AHAM Standard DW-1 for the types of soil and, most importantly, the amounts of soil is essential in relating each of the three soil levels to an amount of soil.

The relationship to the amounts of soil representative of the soil levels is derived differently for each survey, but for each survey the relationship is made in terms of the number of place settings in the DOE test load that are soiled according to ANSI/AHAM Standard DW-1. The author(s) of survey C make the relation from the extensive descriptions in their survey data to an associated amount of soil in terms of DW-1 soiled place settings. For survey D the respondents directly make the link to an amount of soil in terms of DW-1 soiled place settings. For survey F, Arthur D. Little has made the link from the survey's description of its soil categories to an amount of soil in terms of DW-1 place settings.

Table 3 shows the range of the survey data on representative amounts of soil for each of the three soil levels. For each survey the amounts of soil are expressed in terms of the number of place settings in the DOE test load that are soiled according to ANSI/AHAM Standard DW-1.

Table 3 – Range of Survey Data on the Representative Amounts of Soil in the Three Soil Levels

	Soil Amounts in terms of Place Settings Soiled Per DW-1		
	Light	**Medium**	**Heavy**
Survey C	1/2	2	5
Survey D	1-2	4-6	8
Survey F	1	4	8

Aggregating the survey data in Table 3 is not as straightforward as it was in previous sections. Only survey C is nationally representative while surveys D and F are regional. Although this difference alone is not necessarily a concern, this difference in combination with the differences in the representative amounts of soil between the nationally and regionally representative surveys presents a challenge. The depth, breadth, and national representation of the data available in survey C suggest that its representative amounts of soil for the three soil levels alone could be taken to represent U.S. households. However, including data from the narrower scopes of surveys D and F would yield more conservative, that is greater, representative amounts of soil for the three soil levels.

Taking the more conservative path, surveys C, D, and F were aggregated to yield representative amounts of soil for each of the three soil levels. However, before aggregating these surveys the data from survey D needs to be treated carefully.

As discussed previously, survey D shows the same distribution of respondents as in surveys C and F (also survey A) for the light level of soil, which is approximately 62%. At the medium and heavy levels of soil survey D departs from the other surveys showing rather a distribution of approximately 21% at the medium level and 17% at the heavy level. The author(s) of survey D noted concerns that

some number of their respondents were not properly instructed on this question and may have skewed their responses to the heavy soil level.

The author(s) of survey D intended that respondents select one of several images that most closely represents the amount of soil typically found on each piece of dishware in their dishwashers. Some respondents did not receive clarification on this instruction and / or may have misinterpreted this instruction to mean "select one of the several images that most closely represents the total amount of soil on the dishware in their dishwashers." Certainly this misinterpretation would introduce an upward skew to any of the responses in survey D, not just those in the heavy soil level as the survey author(s) indicated. This means that its light soil level may be underestimated, its medium level may or may not be impacted, and the heavy level may be overestimated.

Given that some number of respondents may have taken this interpretation, there is cause to question survey D in general. However, for the purpose of a conservative aggregation of surveys C, D, and F, survey D can be included without great concern for overestimation, if its responses in the heavy soil level are completely discounted. In the following aggregation survey D is included without its responses at the heavy soil level.

Figure 4 show the distribution of responses from surveys C, D (modified), and F on representative amounts of soil corresponding to the three soil levels – Light, Medium, and Heavy. Calculating the weighted averages of the responses for each level of soil yields conservative values for the representative amounts of soil in each of the three soil levels found in the dishwashers of U.S. households. Table 4 shows these results.

Figure 4 – Distribution of Survey Respondents on Representative Amounts of Soil in Each of the Three Soil Levels

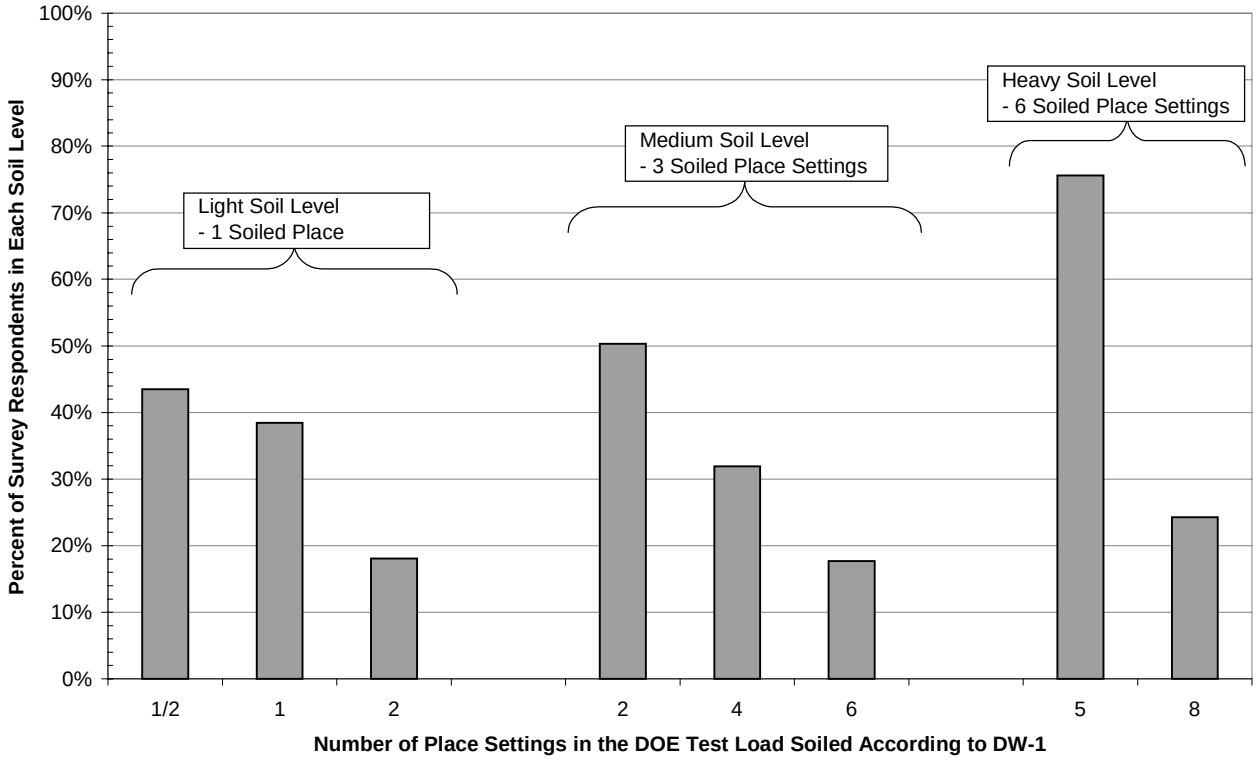


Table 4 – Representative Amounts of Soil in Each of the Three Soil Levels Found in Dishwashers of U.S. households

	Soil Amounts in terms of Place Settings Soiled Per DW-1		
	Light	**Medium**	**Heavy**
Weighted Average	**1**	**3**	**6**

How are the dishwashers loaded in U.S. households?

This section considers the information available in surveys A and C to understand how many dishes and what type of dishes should be in the test load(s) of DOE's energy consumption test procedure.

Quantity of dishware

The available survey information clearly indicates that in the vast majority of households (> 80%) dishwashers are run at full capacity. Given the directness of this finding, it is recommended that the eight place settings test load called for in the existing test method should be retained and applied to any revisions to the test method for soil-sensing dishwashers.

It is interesting to note the implication of this finding in conjunction with the finding on the frequency of use of a dishwasher found in a later section of this report. As most households only operate a dishwasher once it is full, and dishwashers are run about once every other day, then the dishware, pretreated and not, is accumulating over two days. The further implication is that some portion, probably half, of the dishware in the load, pretreated and not, is air-drying for about a day.

The dishwasher industry is aware of the implication that dishware with varying amounts of soil is air-drying prior to running a cycle and that this can affect the cleaning performance of a dishwasher. ANSI/AHAM Standard DW-1 currently calls for a two hours of air-drying for soiled dishware prior to running a test load. AHAM, its members, and other interested groups are reviewing the need to revise the air-drying specification. It is recommended that any revisions to the air-drying specification in ANSI/AHAM Standard DW-1 should be automatically included in the revised test method for soil-sensing dishwashers as it is an integral part of a soiling procedure dishware.

Type of dishware

The available survey information indicates, as might be expected, that there is a wide variety of dishware used in U.S. households. However, survey A offers some information on the material type of dishware. Survey A indicates that for more than half of the households surveyed, plastic dishware makes up a quarter or more of the dishwasher loads.

The impact of a portion of the test load being made up of plastic dishware is unknown. However, any impact is likely to be of secondary importance to implementing a soil-based test method for soil-sensing dishwashers. Therefore, it is recommended that a revised test method for soil-sensing dishwashers use the uniform set of ceramic dishware and glassware referenced in the current test method. As a future effort the impact of plastic dishware may be assessed and considered in later revisions to the test method.

How to reflect soiling in a modified energy consumption test method?

This section presents an approach to modify the energy consumption test procedure for dishwashers to consider soil-sensing dishwashers. The proposed approach follows directly from the above findings.

Proposed Energy Consumption Test Method

This proposed revision to the energy consumption test method for dishwashers applies only to soil-sensing dishwashers. The revision would create two paths in the test method. One path for non-soil-sensing dishwashers would follow the existing test method. The other path for soil-sensing dishwashers would follow the outline below for a revised test method.

The revised test method requires three energy consumption tests using different numbers of soiled dishware. To cover the distribution of soil levels in the dishwasher loads of U.S. households, the energy consumption of soil-sensing dishwashers needs to be measured at each of three soil levels – Light, Medium, and Heavy- creating a three-point test method. The amount of soil at each of the soil levels is defined by the number of place settings out of the eight place settings in the existing test load that are soiled in accordance with ANSI/AHAM Standard DW-1. The number of soiled place settings in the test load at each of the soil levels is shown in the test schedule in Table 5.

Table 5 – Test Schedule for Soil-Sensing Dishwashers

Test Number	Soil Level	Soiled Place Settings per AHAM Standard DW-1	Clean Place Settings per AHAM Standard DW-1	Total Place Settings
1	Light	**1**	7	8
2	Medium	**3**	5	8
3	Heavy	**6**	2	8

Note that the six serving pieces called for in the existing test method would be included clean.

The energy consumption for each of the three tests would be measured and calculated in the same way as the existing test method. However, the energy factor for a soil-sensing dishwasher would be based on a weighted average of the three energy consumption tests. The weighting factors are the percentages for the distribution of U.S. households in the three soil level categories – 62% Light level of soil, 33% Medium, and 5% Heavy (see Figure 2).

Incorporating the weighting factors with the energy consumed in each test yields an energy factor for soil-sensing dishwashers as defined in Equation 1.

Equation 1 – Energy Factor for Soil-Sensing Dishwashers

$$EF_{soil\text{-}sensing} = 1/((.62*\text{Test \#1 Energy})+(.33*\text{Test \#2 Energy})+(.05*\text{Test \#3 Energy}))$$

How often do U.S. households use a dishwasher?

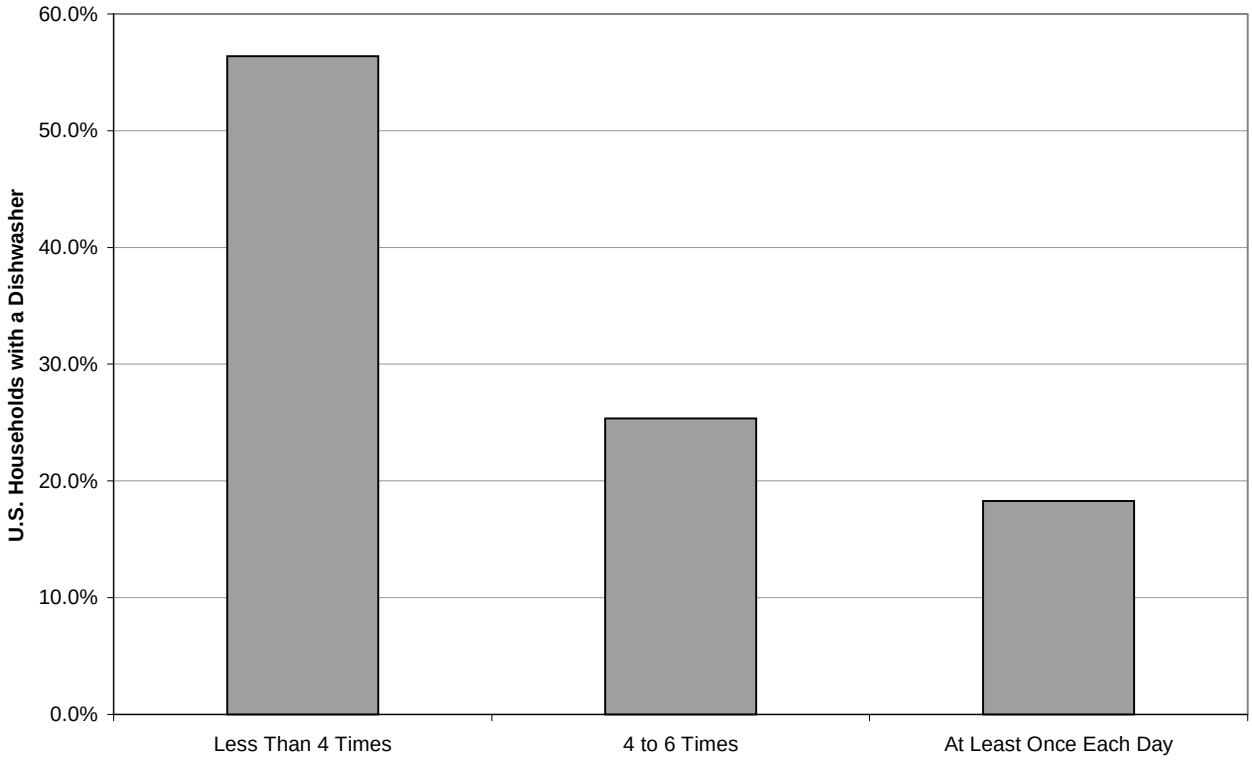
Frequency of households' usage of a dishwasher

Surveys from six of the eight sources present information on the frequency of households' use of a dishwasher. Five of the six surveys (surveys A, B, G, H, and 1997 RECS) are nationally representative and cumulatively represent over 20,000 U.S. households.

One of these five surveys is the Energy Information Administration's 1997 Residential Energy Consumption Survey (1997 RECS). The 1997 RECS data on the usage of a dishwasher, as shown in Figure 5, indicate that more than half of U.S. households with a dishwasher use it less than 4 times per week. Therefore, the number of representative average-use cycles per year for a dishwasher should be in the vicinity of 208 cycles per year.

Although this is far fewer cycles per year than the 264 cycles per year recommended in an interim rulemaking on dishwashers, it is not inconsistent with the steady decrease over the past 20 years in the average-use cycles for a dishwasher. EIA's data are far more recent than the data available for the interim rulemaking that recommends 264 cycles per year. The 264 cycles per year in the interim rulemaking is based on an average of data gathered between 1985 and 1995.

Figure 5 – 1997 RECS-Usage of a Dishwasher



However, calculating an average value for usage of a dishwasher from the RECS data is not straightforward. To determine an average requires definition of a single value for each category that is to be weighted by the percentage of responses in that category. The categories, "less than 4 times" and "at least once each day", do not define a single value and therefore, make determining an average somewhat arbitrary.

The issue in determining an average is not limited to the RECS data. Several of the other surveys share the problem of defining a single value for a category, but to a much less extent than the RECS data. Generally the other surveys minimize this issue by including more categories, by better distributing categories, and by having more bounded categories.

To analyze the frequency of use data a consistent approach was used to estimate values for the surveys' categories. A low value, an average value, and a high value were defined for each category found in the surveys. For bounded categories, such as "3-4 times per week", the low value was 3, the average value was 3.5, and the high value was 4. For upper bounded categories, such as "once a month or less", the low value was taken as 1 per 6 weeks, the average value was taken as 1 per 5 weeks, and the high value was taken as 1 per 4 weeks. For lower bounded categories, such as "at least once per day", the low value was taken as 7 per week, the average value was taken as 8 per week, and the high value was taken as 9 per week.

The five nationally representative surveys, including the RECS data, were analyzed in this way. Table 6 shows the range of average-use cycles calculated using the low, average, and high values for the categories in each survey. On inspection of Table 6, it is clear that the surveys' data on average frequency of use falls roughly in two groups – less than 206 cycles per year and greater than 206 cycles per year.

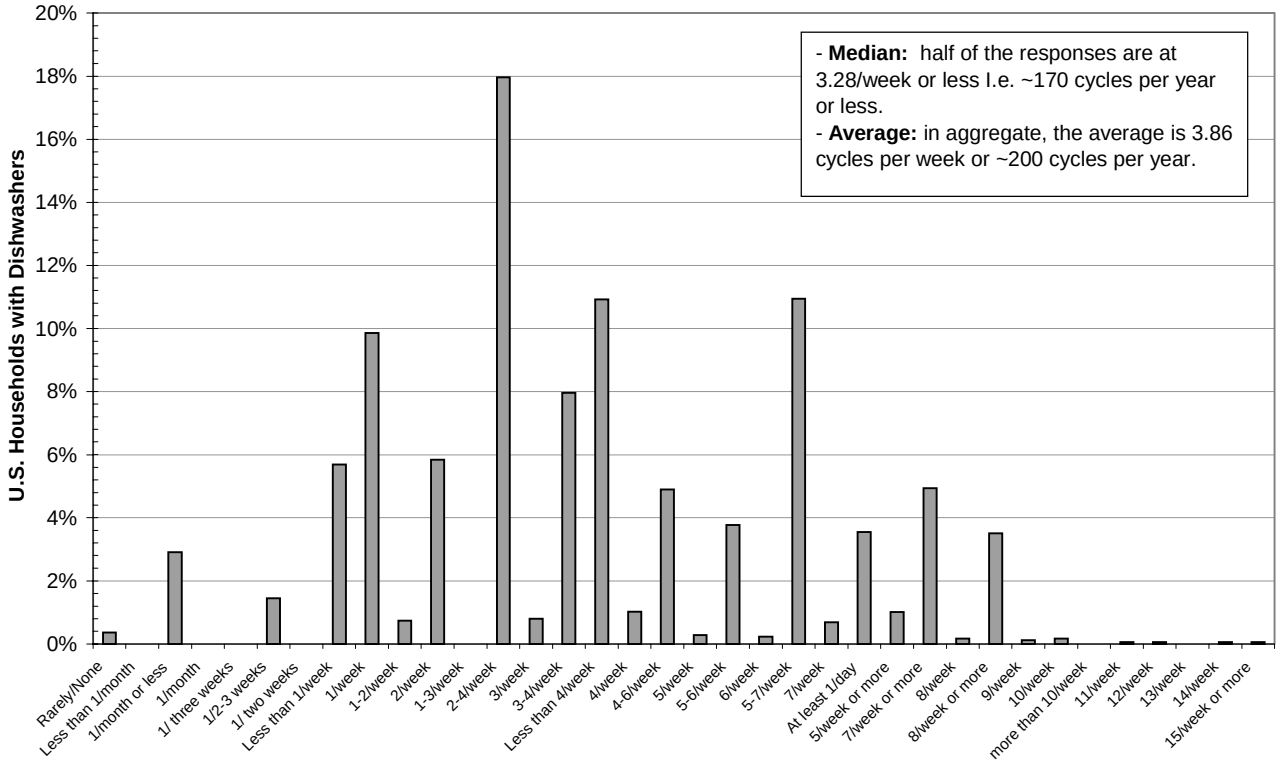
Table 6 – Range of Average-Use Cycles / Year for a Dishwasher

	Range of Average-Use Cycles / Year for a Dishwasher		
	Low Category Values	**Average Category Values**	**High Category Values**
Survey A	162	181	201
Survey B	153	191	230
Survey G	155	189	224
Survey H	225	225	226
1997 RECS	207	245	282
Average of Averages	***180***	***206***	***233***

Another approach to reduce the surveys' data to a value for the representative average-use cycles per year is to consider the distribution of responses for the categories of the five nationally representative surveys as shown in Figure 6. In aggregate the five nationally representative surveys indicate that half of U.S. households with dishwashers use their dishwashers less than 170 times per year.

Again calculating an average of these categories requires definition of a single value for each category. By applying the average value for each category, as in the above discussion, to the distribution in Figure 6 an average weighted by the number of respondents in the five nationally representative surveys can be calculated. This calculation yields a weighted average of 200 cycles per year.

Figure 6 – Distribution of Frequency of Households' Use of a Dishwasher



The previous discussions on the frequency of use of dishwashers in U.S. households suggest that the representative average-use cycles per year for a dishwasher should be at least 200. Additional data from the dishwasher detergent industry is being sought to refine further the number for the representative average-use cycles per year. This additional data is anticipated for late December 2001 or early January 2002. Without regard for this additional data it is clear that a revised number for the representative average-use cycles per year should be substantially less than the 264 in the interim rulemaking, but not less than 200 cycles per year.

Recommendations

The following is a summary of Arthur D. Little's recommendations on revisions to the Department of Energy's test procedures for measures of energy and water consumption and their "Uniform Test Method for Measuring Energy Consumption of Dishwashers". Arthur D. Little's recommendations on revisions to the test procedure include:

- Creating a separate path in the test method for soil-sensing dishwashers and adopting the three point test method for soil-sensing dishwashers outlined above, and
- Reducing the average-use cycles per year for dishwashers into the range of 200 to 233 cycles per year.

In addition to these revisions to the test procedure, there are several other recommendations for future actions to capture greater efficiency benefits with dishwashers and to maintain the test procedure for dishwashers:

- Assessing the energy impact of pretreating dishes and the energy saving opportunities of greater utilization of dishwashers,
- Supporting industry efforts to update and maintain the ANSI/AHAM Standard DW-1,
- Assessing the energy impact of plastic dishware in the test load, and
- Monitoring and updating the distribution of households with dishwashers by the level of soil in the load through a follow-up assessment of households' dishwasher usage habits and characteristics.